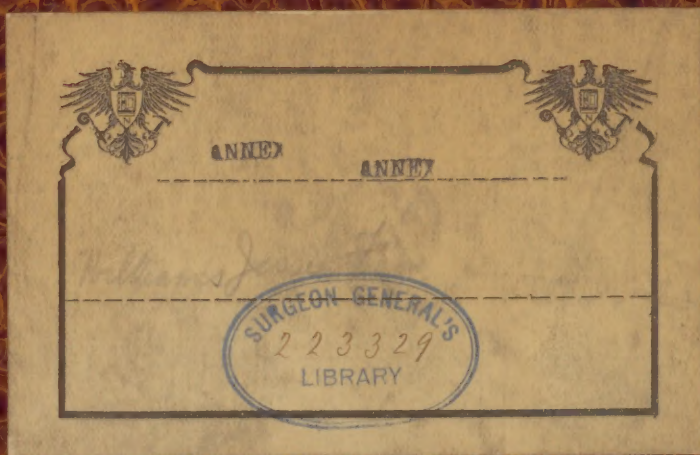


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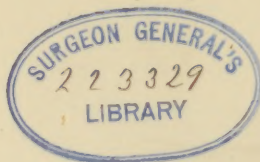
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LABORATORY COURSE
IN
APPLIED PHYSIOLOGY

PHYSICAL EDUCATION DEPARTMENT
TEACHERS COLLEGE
NEW YORK

✓
JESSE FEIRING WILLIAMS, A. B. M. D.

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APPLIED PHYSIOLOGY—LABORATORY

I.

1. Use of Microscope.

- (a) Ocular, objective, power, shutter.
- (b) Place specimen of onion root on slide. Observe and draw several cells showing:
 - (1) Cell outline (limiting membrane)
 - (2) Protoplasm of cell (cytoplasm)

What are the properties common to all living cells?

2. Use of du Bois-Reymond coil.

- (a) Arrange battery with key in circuit to connect with posts 1 and 2 of coil. This will give a simple induced current.
- (b) Observe that current may be made with "make" or "break" shocks. Which is stronger? Test on tongue.
- (c) Close the circuit and observe that in this way you may use either "make" or "break" shocks alone.

3. Stimulation of Muscle.

- (a) Amputate the leg of a recently killed frog at its articulation with the pelvis. Strip off the skin and free the sciatic nerve along its course to its ending in the gastrocnemius muscle. Cut away the thigh muscles, leaving the gastrocnemius attached at its central end to bone. Sever its distal end, the tendon Achilles. Place in muscle clamp and attach the writing lever. This is a "muscle-nerve preparation."
- (b) Stimulate with single "make" or "break" induction shocks recording on the kymograph the result, moving the drum by touch. Which gives the stronger contraction? What does that mean?
- (c) Pinch the sciatic nerve with forceps. Notice the result and record all observations.

II.

I. Different Kinds of Cells.

1. Observe under the microscope sections of smooth, striated and cardiac muscle. Draw the striated picture. Explain the action of the Light and Dim bands in muscular contraction.
2. With the oil immersion lens, observe blood cells and draw several.

II. Demonstration of Chemical and Electrical Action.

1. Into a test tube is placed zinc and water and then sulphuric acid is poured into the tube. The action resulting is chemical in nature and heat is produced. The energy formed in this chemical action expresses itself here as heat.
2. A voltaic cell, made by placing a copper and zinc strip in a 20% solution of sulphuric acid, is connected by two wires to an indicator. The energy generated by the chemical action expresses itself here as electricity.

Explain the analogy between muscle and nerve.

III.

1. Stimulation of Muscle.

Kill (pith) a frog and suspend the animal from muscle clamp by its lower jaw passed thru a pin hook. Pinch the toe or foot with forceps. What happens? This is a reflex muscular action. Repeat the stimulation by dipping the foot into dilute acetic acid. Notice results. Stimulate with "break" shocks. Compare results. Destroy spinal cord with a wire and repeat experiments. What has happened? Trace the course of the stimulus over afferent nerve and efferent nerve.

2. Stimulation and Recording of Muscle.

Prepare a "muscle-nerve preparation." Be very careful not to pull the nerve. Do not pinch it. Take time to separate it carefully. Keep specimen moistened with saline. Arrange on muscle clamp and attach writing lever. Stimulate with single "make" and "break" shocks, recording the result on kymograph, moving the drum by touch. Which gives the stronger contraction? Upon what does the strength of a muscular contraction depend?

3. Stimulation of Muscle by Tetanic Current.

With "make" and "break" shocks stimulate the nerve of preparation. In the relaxation phase stimulate again. Do this at frequent intervals. Arrange posts 1 and 3 with battery and stimulate with tetanic current. What is a tetanic current and what is a tetanic contraction? Do human muscles move by tetanic contractions?

IV.

1. Muscle Tonus.

Kill (pith) a frog. Divide the roots of the sciatic nerve on its emergence from the cord on one side. Suspend the frog by its lower jaw on a pin-clamp. Note any difference in the two legs. Explain the result.

2. Action Current of Muscle.

Kill a frog and prepare both muscle-nerve preparations. Lay one preparation on a plate and lay the nerve of other preparation on the muscle of the first. Stimulate the free nerve by frequently repeated induction shocks. Observe what happens in the second muscle. Explain!

3. Latent Period in Muscular Contraction.

Arrange a muscle-nerve preparation in muscle clamp and attach writing lever. Arrange signal in same vertical plane with lever. Stimulate with single induction "make" or "break" shock. Spin the drum by hand, make record with a tuning fork and record muscular contraction. Draw perpendiculars and determine the time of latent period, phase of contraction and phase of relaxation.

4. "Die Treppe."

With a muscle-nerve preparation in muscle clamp and attached to writing lever, record contractions of muscle on drum with "break" shocks only. Use a moderate stimulus, keep it constant and have the drum revolving slowly. To what is the staircase due? Why should athletes "warm up" before beginning an event? Are there other reasons besides "Die Treppe?"

V.

1. Action of Temperature in Muscular Contraction.

Arrange muscle-nerve preparation by small copper wires to moist chamber apparatus and writing lever above. Attach one wire to lever-screw on writing lever and one around cap of moist chamber. Let upper wire run over wheel in lever. Surround the chamber with ice-water, take temperature and record contraction when near zero. Raise the temperature by heating outside beaker. At 5° variation in temperature record contraction until rigor caloris is reached. Have drum revolving slowly. Remove and examine the muscle.

2. Representation by Curve.

Draw ordinates and abscissas and represent the 5° temperature variation on the axis of abscissas. Measure height of contractions in centimeters and represent as ordinates. Make curve by plotting the points obtained.

3. Application—Effect of Cold and Heat on Muscular Contraction.

(1) Cool the hand and arm up to the elbow in ice water, so as to involve the flexors. Make in three trials, the maximal contraction on dynamometer.

(2) Warm the hand and arm with heat and massage. Make in three trials the maximal contraction on dynamometer.

What do these experiments suggest for athletics in particular and physical education in general?

4. Reference Reading:

Lombard W. P.—Am. Jr. Phy., Vol. XIII., 1892, parts 1 and 2.

VI.

1. Height of Contraction in Relation to Load.

Prepare a muscle nerve preparation, arrange in muscle clamp and attach writing lever. Place kymograph for recording contractions. Stimulate with maximal break shocks. Have the weight pan empty and successively loaded with twenty gram weights until the load is too great to be lifted. Record each contraction from the same base line and between successive contractions move the drum by hand one centimeter. Notice the greatest contraction and record under each contraction the load in grams.

2. Work Performed.

Measure in millimeters the total length (L) of the writing lever from its axis to its tip; the length (l) from its axis to the muscle attachment; and the height (H) of each contraction as recorded on the kymograph. The actual shortening of the muscle or the actual height the different weights are lifted, is indicated by the following diagram, in which

$$L : H :: l : h$$

$$\text{and } h = \frac{Hl}{L}$$



Find h in each contraction of the series above in which L and l are constant and H variable.

Using the formula,

$$W = w \times h$$

calculate in gram-millimeters the work performed. W = the work done; w the weight lifted; and h the height to which it is lifted.

Notice with what load the muscle performs the greatest work.

3. Curve of Work.

Plot the curve of work on co-ordinate paper and use weight for abscissa and work done for ordinate. What three facts are expressed by this curve of work? How can one utilize those facts in prescribing exercise on the pulley weight?

Reference Reading:

Frantz S.—Am. Jr. Phy., Vol. IV., 1900.

VII.

1. Spreading of Impulses.

Kill (pith) a frog, destroying the brain completely and suspend the animal from a pin hook, attached to a muscle clamp. Place a piece of acid (acetic) soaked filter paper on the ventral surface of one thigh. Hold that leg by the foot and watch the other leg. Explain what is happening in the cord.

2. Summation of Subminimal Stimuli.

Kill (pith) a frog, destroying the brain completely and suspend from a pin hook. Attach two flexible electrodes around the frog's foot at a distance of one centimeter. Stimulate by means of make shocks, so small, that no one shock will cause a contraction. Continue the stimulation and notice the summation.

Record instances of summation in other spheres of action.

3. Fatigue of Muscle.

- (a) Record on slowly moving drum a single maximal contraction of a fresh gastrocnemius of a frog. Remove drum and stimulate muscle 25 times. Record on moving drum at same point the 26th contraction.
- (b) Stimulate 50 times and record the 77th contraction in like fashion.
- (c) Stimulate 75 times and record the 153rd contraction in like fashion. Use "break" shock in all stimulations.

4. Fatigue of Nerve.

Arrange fresh muscle, stimulate the nerve every two seconds until muscle is completely fatigued as shown by record. Apply stimulus directly to muscle. What is the result? Explain it.

- 1. Name the products which cause fatigue. How are they eliminated from the system?
- 2. What conditions cause fatigue to appear in the child?
- 3. Does the "plateau" have any bearing on the teaching of children as regards fatigue?
- 4. What does La Grange think about fatigue as compared with O'Shea.
- 5. What bearing has physiology on the subject of physical exercise? F. S. Lee, A. P. E. R., Apr., 1909, 14: 216.
- 6. What is the nature of fatigue? F. S. Lee. Pop. Sci. Mo., Feb., 1910, 76: 182-195.

VIII.

Reaction Time in the Nervous System.

1. Reaction to Touch.

Arrange a signal and two keys in the primary circuit of the induction apparatus. Place kymograph with smoked paper ready to receive the marking of the signal and have ready for recording the vibrations of a tuning fork with above. Let subject hold the electrode from secondary coil on tongue and with other hand hold one key closed. The observers shall then spin the drum, record fork and close the other key. When the subject feels the make shock, let her break the circuit by opening her key. Draw ordinates and determine the reaction time. Repeat three times and take an average.

Repeat with a stronger stimulus. What relation is there between strength of stimulus and reaction time? Where in the nervous system is there this delay in response and to what is it due?

2. Reaction to Sight.

Repeat above experiment as to form, but instead, connect two wires going to a signal. Let subject open key when movement of the lever is perceived.

3. Reaction to Sound.

Repeat above experiment as to form, but let subject open key when the sound of key closing is heard.

How may an individual's reaction time be judged in athletics? Should Physical Education training shorten the reaction time? Of what practical advantage would this be?

IX.

1. Schema for Circulation.

(a) Identify on circulation scheme the heart, aorta, arteries, capillaries and veins.

(b) When capillaries are shut down what effect has that on the resistance and on the pressure?

(c) When capillaries are open what is the nature of the flow? Why? Is this condition seen in the body? Produce a type of flow that is present in the body.

(d) What effect has increased resistance on pressure and on velocity? How is such effect produced in the body?

2. The Circulation—Heart.

Pith a frog and open the chest by carefully cutting away the shoulder girdle. Expose the heart. Watch the beating heart. Identify systole and diastole. How would you describe each? What starts systole?

3. Blood Pressure Schema.

Fill a bell jar with water and demonstrate the increase in arterial pressure with vaso-constriction of the arterioles. Draw diagram to illustrate the condition.

4. Osmosis.

Place an animal membrane over an inverted thistle tube, fill to neck with saturated solution of magnesium sulphate, arrange on stand at same level of surrounding water in a beaker.

5. Assignments.

American Physical Education Review:

December, 1905—Vol. X—No. 4—"Blood Pressure," Crampton.

March, 1906—Vol. XI—No. 1—"Blood Pressure," Crampton.

X.

1. Blood Cells.

Observe slide of frog's blood. Draw cells seen. How do they differ from human blood.

2. Blood Smear.

With sterile gauze wash off the end of the little finger with 70% alcohol. With sterile needle prick finger and obtain a drop of blood. Make a smear on a slide with another slide and stain.

Dry, blot, observe, and draw cells seen under the microscope. What are the functions of the cells seen?

3. Coagulation.

Kill a frog and bleed into a glass beaker. Watch it harden and the clot separate. What causes the blood to clot? Is clotting valuable in the life of an individual?

4. Assignment.

A. P. E. R.—Article by C. W. Crampton on Blood Pressure.

June, 1906—Volume XI—No. 2.

Sept., 1906—Volume XI—No. 3.

XI.

Mechanism of Respiration.**1. Schema.**

Locate upon the respiration scheme what corresponds to the following structures:

- (a) trachea, (b) glottis, (c) thoracic cavity, (d) lungs, (e) intrapleural space, (f) diaphragm.

2. Produce Inspiration by Lowering Diaphragm.

- (a) What has happened to the intra-thoracic pressure?
- (b) What has happened to the intra-pulmonic pressure?
- (c) How does the pressure in each case compare with atmospheric pressure in inspiration and expiration?
- (d) Compare intra-thoracic and intra-pulmonic pressures.

3. Produce Expiration by Raising the Diaphragm.

Answer (a), (b), (c), (d) for this procedure.

4. Produce a Condition of Pneumothorax. Lower the Diaphragm as in Inspiration.

What effect does this have upon the expansion of the lungs? Account for it. What change is there in intra-thoracic pressure as a result of lowering the diaphragm?

5. Close the Glottis after Expiration. Lower the Diaphragm as in Inspiration.

- (a) What effect does this have upon the expansion of the lungs?
- (b) What change is produced in intra-thoracic pressure. Account for it.

6. Close the Glottis after Deep Inspiration. Raise the Diaphragm as in Expiration.

What effect occurs upon the lungs and intra-thoracic pressure $\frac{1}{2}$? What effect upon the abdominal pressure occurs in the living subject with the same condition?

7. Reference Reading.

Fitz—Jr. of Exp. Medicine, Jan., 1896. "Respiration."

XII.

1. Respiration Schema.

Arrange apparatus and fill bulb with water. Raise and lower water diaphragm and produce respiration in the mechanism. Watch the indication of pressures by the mercury columns. Name lungs, trachea, thoracic cavity, diaphragm, pleura, intrapulmonic cavity, etc.

2. Spirometer.

Explain the construction of the instrument. What is it devised to measure? What does it tell about the condition of the lungs, about the mobility of the chest wall, and action of the diaphragm?

1. Measure the tidal air.
2. Measure the supplemental air.
3. Measure the vital capacity.
4. Measure the vital capacity with 2 A. elevation sideward on inspiration and sinking on expiration.
5. Measure the vital capacity with 2 A. elevation sideward upward on inspiration and sideward downward on expiration.

Of what value are respiratory exercises as given in the gymnasium?

XIII.

1. Forced Breathing and Apnea Vera.

(a) Subject seated breathes as deeply as possible about 18 times a minute. Attention should be fixed on drawing deep inspirations. The process is continued for 30 seconds (nine respirations). Count normal rate before and after experiment and notice normal depth of respirations. Record with pneumograph all observations.

(b) Repeat experiment for a one-minute period.

(c) Record any subjective sensations.

(d) Repeat experiment for a two-minute period and record any subjective sensations.

2. Forced Breathing Without Excessive Elimination of Carbon Dioxide.

Repeat 1 (a) while holding a paper bag over nose and mouth of subject. Record results and explain the condition in the light of experiment 1. Record observations on pneumograph.

Reference Reading: Howell, "Text book on Physiology," chapters 36, 37, 38.

XIV.

1. Voluntary Apnea.

Subject holds breath at end of expiration, until no longer able. How long can it be held?

(a) Repeat experiment (1) after taking a deep inspiration and counting from end of moderate expiration. How long can it be held?

(b) Subject performs forced breathing for 2 minutes. Measure from end of moderate expiration how long breath can be held.

Explain why one must breathe and why there is a variation in 1, 2 and 3.

2. Assigned Reading:

Howell. "Text Book of Physiology." 672m—688t (inclusive).

XV.

I. Respiration in a Mammal.

Anesthetize a mammal and maintain the anesthesia throughout the experiment until animal has been killed. Make a longitudinal ventral incision and expose ribs and abdominal muscles. Open the abdominal cavity and study action of the diaphragm. Describe the mechanism of respiration. Observe the lungs thru the pleura of an intercostal space after removing muscles.

Remove lungs and drop in water. Do they float? Why?

Place lungs in the respiration model in place of rubber bag and study action of lungs.

II. Dissection.

With a scalpel work out a muscle, a tendon, a ligament, the peritoneum.

Study the arrangement of the mesentery and intestines.

What is enteroptosis? How does posture in relation to the anatomical and physiological facts involved control the condition?

Describe the effects of poor posture upon respiration.

XVI.

Heart Rate and Exercise.

1. Palpate the pulse in radial, temporal and carotid arteries. What causes the pulsation?
2. Count the radial pulse during four consecutive 15-second periods in
 - (a) Horizontal position face up
 - (b) Horizontal position face down
 - (c) Sitting position
 - (d) Standing position
 - (e) After 10 deep knee bendings.

Does it vary? Why? (Allow two minutes between each change.)

3. Count the radial pulse during four consecutive 15-second periods.
 - (a) Subject holding breath during 2 middle periods.
 - (b) Vigorous expiratory efforts during the 2 middle periods.
 - (c) Grasp tightly with both hands showing "effort" during the 2 middle periods.

Explain any variation that may occur. Is it constant for all groups in class?

4. Count the radial pulse during four consecutive 15-second periods. Compare rate and regularity in frequency of pulse during natural respiration and increased respiration after 20 deep knee bendings. What are respiratory irregularities?

Reference Reading: "Clinical Disorders of the Heart Beat"—Thomas Lewis, pages 11b—15b.

XVII.

Exercise and Blood Pressure.

1. (a) Count heart rate of subject standing during four consecutive fifteen second periods.
(b) Record blood pressure and make tracing with sphygomanometer.
2. (a) Let subject make 60 flexions and extensions of arms in 60 seconds with an 8-lb. dumb bell. Count heart rate standing during the four consecutive fifteen second periods.
(b) Record blood pressure and make tracing with same subject.
3. a() Let fresh subject make 30 deep knee bendings in 60 seconds, first counting the normal rate standing and recording blood pressure.
(b) Record blood pressure and make tracing.
4. (a) Let fresh subject make a stationary run for one minute with knees coming up high, first counting the normal rate standing.
(b) Record blood pressure and make tracing before and after exercise.

Assignments:

Martin—pp. 325-327.

Howell—pp. 473-494.

Crampton—A. P. E. R., Dec., 1906. Vol. XI. No. 4.

XVIII.

Exercise and Blood Pressure.

Take blood pressure tracing and reading and heart rate during four consecutive fifteen second periods. Let subject run $\frac{1}{4}$ mile* in about one minute. At once afterward take blood pressure and heart rate, repeating every second minute for thirty minutes.

Name:

Before Run: Time.....B. P.....H. R.....(1).....(2).....(3).....(4).....

After Run: Time.....B. P.....H. R.....(1).....(2).....(3).....(4).....

Assignment:

La Grange—"Physiology of Exercise," pp. 3-19.

Mackenzie—"Exercise in Education and Medicine," pp. 315-24.

Crampton—A. P. E. R., March, 1907. Vol. XII. No. 1.

* 19 27/100 laps 18" from outside = 1 mile. (Thompson Gymnasium.)

XIX.

Exercise and Blood Pressure.

(1) Take blood pressure tracing and reading and heart rate during four consecutive fifteen second periods. Let subject run $\frac{1}{2}$ mile. At once afterward take blood pressure and heart rate, repeating every second minute for thirty minutes.

Name:

Before Run: Time.....B. P.....H. R.....(1).....(2).....(3).....(4).....

After Run: Time.....B. P.....H. R.....(1).....(2).....(3).....(4).....

(2) Take blood pressure tracing and reading and heart rate during four consecutive fifteen second periods. Let subject who acted in XVIII. work for the same period of time as last week and perform exercises of strength. Use the back and leg dynamometer. Record results and compare with results in XVIII.

Assignment:

Crampton A. P. E. R., June, 1907. Vol. XII., No. 2.

Crampton A. P. E. R., Sept., 1907. Vol. XII., No. 3.

XX.

Exercise and Respiration.

1. Run twice around the track at a speed that is moderately fast for you.
 - (a) Notice the type of respiration afterwards.
 - (b) Which is longer—inspiration or expiration?
 - (c) Has your respiration increased in rate? Why?
2. Run rapidly around the track until dyspnea occurs.
 - (a) What part of your respiration is difficult? Explain it!
 - (b) What is the condition of the lungs as regards blood supply during the process? Account for it!
3. Run at a regular pace, taking equal steps. Inspire and count number of steps up to the time when expiration is absolutely necessary. Rest and then repeat for expiration. Rest and run, counting steps for three successive respirations with the notation of the number in inspiration and expiration. Record results! Explain!
4. Constrict the waist and lower chest with a wide sash and repeat experiment 3. Account for the results! What practical hygienic value has this?

Assignment:

La Grange—"Physiology of Exercise" (entire).

XXI.

1. **Fatigue (hand ergograph).**

Arrange the ergograph for recording. Securely fasten the second, third and fourth fingers to the wooden support. With the upright rod resting on the distal end of the middle phalanx, record upon a slowly moving drum:

- (a) A series of **maximal** contractions of the **abductor** indicis muscle at the rate of electric indicator for 10 minutes. Does fatigue take place?
- (b) A series of very rapid **maximal** contractions for five minutes.
- (c) After resting the muscle used in (b) for 10 minutes, repeat experiment (b).
- (d) Make a tetanic contraction.

What do the results of the previous experiments show regarding the onset of fatigue and its duration?

2. **Reference Reading.**

- Maggiora A.—Archiv. für Anat. u Phy. 1890. "Über die Gesetze der Ermüdung."
Lee, F. S.—Pop. Sci. Mo., 76: 182-95, February, 1910. "Nature of Fatigue."

XXII.

1. Fatigue (spring ergograph).

Arrange ergograph at proper height so operator can sit by its side. Arrange revolving drum in contact with recording lever. Make maximal contractions with middle finger at the rate of electric indicator adjusted to three different speeds.

Is there "Die Treppe" present?

What products cause local fatigue here?

How can their effects be overcome?

Does that apply to general fatigue?

2. Reference Reading.

Hough, Theo.—Am. Jr. Phy., Vol. 5, 1901. "Ergographic Studies in Neuro-Muscular Fatigue"

XXIII.

Fatigue, Effort, Energy.

1. Using spring ergograph, rapidly make a short series of **maximal contractions** on drum at 1.
2. Do the same at 2.
3. Repeat at 3.
4. Repeat at 4.
5. Repeat at 5.

Between each series rest at least 5 minutes (more if necessary) and become completely rested before doing the next.

Reference Readings:

James—"Talks to Teachers."

1. What does La Grange think about fatigue as compared with O'Shea?
2. How are fatigue substances eliminated from the body?

Assigned Reading:

Am. Phys. Ed. Review—F. S. Lee, April, 1909. 14:216.

Pop. Soc. Mo.—F. S. Lee, Feb., 1909. 76:182-195.

XXIV.

1. Hemoglobin.

Demonstration of methods for measuring the hemoglobin content of the blood:

- (a) What is hemoglobin?
- (b) How may it be increased?
- (c) What are the social, economic and biologic factors making for a low hemoglobin content?

2. Reference Reading.

Howell, W. H.—Text-book of Physiology, pp. 408t-429b.

Wood, F. C.—Chemical and Microscopical Diagnosis, pp. 10b-33b.

XXV.

1. Urine.

Demonstration of methods for examining the urine.

(1) Specific gravity:

- (a) The specific gravity of the urine in relation to drinking water and exercise.
- (b) Its significance in relation to training an athletic team.

(2) Reaction.**(3) Albumin:**

- (a) What forms of albumin may be normally present in the urine?
- (b) What is the significance of "athletic albuminuria?"
- (c) Indicate the most desirable test for albumin in the urine.

(4) Sugar:

- (a) Indicate the relation that glycosuria may have to meals, eating of candy and exercise.

2. Reference Reading.

Howell, W. H.—Text-book of Physiology, Chap. XLV.

Wood, F. C.—Chemical and Microscopical Diagnosis, pp. 410t-624t.

Course Physical Education 55-56

Based on Lectures, Martin's "Human Body," and Howell's "Physiology."

I. Muscles:

1. What are the morphological characteristics of a cell?
2. What are the properties of a cell?
3. Define metabolism, reproduction, irritability and function.
4. What is the "optimum point" for a cell? For an individual?
5. In cell specialization what property has the muscle cell developed supremely? The nerve cell? The gastric cell?
6. Describe striated, smooth and cardiac cells.
7. Present the theory of muscular contraction and illustrate with chemical action in producing heat and electricity.
8. How does one develop endurance in the muscle when you consider the function of the sarcoplasm and the fibrils?
9. What is a calorie? State the requirements for man as regards size, age and activity.
10. What is "Die Treppe?" The latent period? The contraction and relaxation phases?
11. What conditions modify the height of a muscular contraction?
12. What application to athletics do you make as regards the effects of temperature?

II. Nervous System:

1. Draw a cross section of the cord and show afferent (sensory), association and efferent (motor) neurones.
2. What is the gray matter? The white matter?
3. Describe a reflex action. What do we mean by the spreading of impulses? Has that any suggestion to make as regards education?
4. What is co-ordination? How is it obtained? What is grace?
5. Why should we not attempt absolute mastery of a movement in any one lesson?
6. What is our "muscle sense?" How does it act?
7. What is inhibition in the nervous system? Explain its action.
8. What can you say about the change going on in every person? Is it visible? Is it inevitable?

III. The Circulation:

A. Blood.

1. What is the blood? What are its functions?
2. Describe the blood cells.
3. What is osmosis?
4. Draw a diagram showing the blood constituents.
5. Describe coagulation.

B. Anatomical.

1. What are the prerequisites for a circulation?
2. Give an anatomical description of the heart and arteries, veins and capillaries.

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C. Mechanical.

1. Draw a schema of the circulation.
2. What is velocity? Blood pressure?
3. Draw diagrams illustrating changes in velocity and blood pressure.
4. What is the normal systolic blood pressure?
5. What is peripheral resistance?
6. Is there any difference between the pressure in the aorta and radial arteries? Explain.
7. How does exercise (muscular contractions) affect the flow of blood and lymph?
8. What is thoracic aspiration?

D. Theoretical.

1. What is systole? Diastole?
2. Describe the systole as seen in the frog's heart.
3. Why does the heart beat? What is the myogenic theory? What is the "Inner stimulus?"
4. Describe the cardiac cycle.
5. Draw a diagram showing ventricular contraction and name its parts. Same for auricle.
6. Give nature and cause of first sound of heart. Same for second sound.
7. What is the normal rate of the heart beat in men, women and children? What is the time of one beat?
8. What is the inhibitory nerve of the heart?
9. What effect has inspiration on the rate?
10. When is an irregularity normal?

IV. Respiration.

A. Anatomical.

1. What is the plan for getting air to the body cells? How does it differ from a unicellular organism?
2. Draw a cross section of an infundibulum showing the relation of the capillaries of lung to the respiratory epithelium.
3. What are the chief muscles of respiration?

B. Mechanical.

1. What is the relation of the lung to the chest wall? Is there any connection between the intrapleural space and the outside air?
2. What enlargements of the chest occur in inspiration? Describe each.
3. What do we mean by vital capacity? Tidal air? Complemental air? Supplemental air? Residual air?
4. Describe the Schaefer method of artificial respiration.
5. What is the intrathoracic pressure? Intrapulmonic? Elastic recoil of lungs?
6. What is the respiratory action of the thorax? (Thoracic aspiration.)
7. What are the advantages of nasal breathing?

C. Theoretical.

1. What is external respiration? Internal respiration?
2. What is the composition of the inspired air? Expired air? What is the main difference?
3. Why does the oxygen pass into the blood and the carbon dioxide pass out?
4. How does arterial blood and venous blood differ in oxygen and carbon dioxide content?

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5. How is the oxygen given to the tissues? Carbon dioxide to the blood from the tissues?
6. What increases gaseous interchange? What factors cause it to vary?
7. To what is the automaticity of respiration due? What factors may influence the respiratory center?
8. Will breathing more air cause more oxygen to be taken to the cells? What significance has this in Physical Education?

V. Digestion and Assimilation.

A. Mouth.

1. What forces are acting in the mouth to prepare the food? Are teeth necessary to health?
2. What is saliva? Name its constituents.
3. What is an enzyme?
4. How can you compare digestion as regards its results to the work of a stone cutter?
5. Name the three food stuffs.

B. Stomach.

1. What does the gastric juice contain? What effect has the mental condition upon digestive juice production?
2. What results from gastric digestion as regards Fats, Carbohydrates and Proteins?
3. Summarize the effects of emotions on digestion (Cannon).

C. Intestine.

1. Draw a picture of a villus.
2. Trace the possible pathways from the intestine for products of digestion. Which way do the fats go? Which way do the carbohydrates and proteins go?
3. Draw a diagram showing the digestive juices and their actions in mouth, stomach and intestine.

VI. Physiology of Exercise.

1. What are the general physiological effects of exercise on the circulation, respiration, skin, nervous system, digestion, kidneys, weight.
2. How will you divide exercise to discuss it physiologically? Why do you make such division?
3. Define exercises of strength. Name four examples.
4. Why do exercises of strength increase intrathoracic pressure?
5. What are the functional and permanent physiological effects of exercises of strength? What pathological effects may result?
6. Give the characteristics of an exercise of speed. Name some examples.
7. Why does speed consume so much more nervous energy as compared to strength?
8. What are the characteristics of an exercise of endurance?
9. Are Marathon races desirable? Why?
10. Will running develop the chest and lungs? How does it act?
11. What German Army experiments with coffee can you cite that show the relation of coffee to endurance?
12. Distinguish between dilatation and hypertrophy of the heart.
13. Are either one desirable? When do they occur?
14. What would you consider a maximum distance race for boys 12-14 years old who were in training?
15. Of what value are exercises of attention and skill?

16. Why do they tend to be psychologically correct?
17. Is interest in physical movement essential?
18. How is interest related to expenditure of nervous energy?
19. What is the effect of mental work upon physical power?
20. What are the differences between athletics and exercises of attention in formal gymnastics?

VII. Breathlessness.

1. What is it? Is it fatigue?
2. What are the factors in its production?
3. Describe the action of the respiratory center.
4. Why do some people become breathless when others do not, in performing the same exercise?
5. Why do people with heart disease get breathless on going up stairs?
6. Is stair climbing good for one? What are the advantages of inclines over stairs?
7. Which is difficult inspiration or expiration?
8. What is "second wind?" How is it produced?
9. What do you mean by the reserve force and the working force of the heart?
10. What do we mean by the phrase, "coefficient of respiratory fitness?" Upon what does this coefficient depend?
11. What accessory factors are prominent in the production of breathlessness?

VIII. Fatigue.

1. Draw a fatigue curve.
2. To what are the symptoms of fatigue due?
3. What practical results as regards fatigue have been demonstrated by the ergograph?
4. What is Die Treppe? To what is it due?
5. Is extreme muscular effort and extreme fatigue desirable? Why?
6. Distinguish between stiffness from new work and stiffness from metabolic products.
7. What is overwork? What metabolic products are concerned in its production?
8. What is exhaustion?
9. What relation does disease bear to overwork?
10. Why should one guard against both the infecting organism and lowered resistance?

IX. Fatigue of the Nervous System.

1. Is there such a thing as pure mental fatigue?
2. What experiment shows a morphological change in nerve cells? This followed physical work. Does that indicate anything for mental fatigue?
3. To what may nervous breakdowns among school children be due besides overwork?
4. Describe metabolic and transferred metabolic fatigue and peripheral sensations causing a feeling of fatigue.
5. What is the treatment for fatigue?
6. What is the value of sleep aside from its value as quiet and physical rest?
7. Explain the effects of fatigue on the Sensations, Perceptions, Self-control, Memory.
8. What is the practical suggestion as regards living from a consideration of such effects?

X. Training—Condition—"Out of Condition."

1. What is training?
2. When is one in condition? Does one lose weight in training? Why?
3. What are the results on the body from training?
4. Give the subjective and objective symptoms and physical signs of staleness.
5. What is a "low protein" diet? How many grams?
6. What is Fletcherism?
7. Is overeating desirable? Why?
8. Should the body lay up a store of fat? Why?
9. Why is ventilation a factor in efficiency?
10. Are strong muscles desirable? Why?
11. What connection is there between bodily vigor and cheerfulness?
12. How do you keep the vaso-motor mechanism in tone?
13. What immediate effect has meals upon the strength of a muscular contraction?
14. Diagram one way of recording a person's physical condition?
15. Describe Dr. Foster's method of testing circulatory condition for athletic competition.

XI. Growth and Development.

1. What is racial recapitulation in the development of an individual?
2. Give the weight of the average boy at 6, 12, 16. Same for the girl.
3. How does a bone grow in length? How in circumference?
4. Is growth in height constant with growth in circumference or alternating?
5. Name the factors influencing growth and discuss them.

XII. The Ear and Eye:

1. Make a drawing showing the structure of the external, middle and inner ear.
2. Explain how ether vibrations reach the organ of Corti.
3. What are the forces acting to produce equilibrium?
4. Make a drawing showing the structure of the eye and one showing the nerve pathways from eye to cerebrum.
5. Give the cause of myopia, hyperopia and astigmatism.
6. What happens when one gets "second sight?"

S. B. L

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